



11/10/03-03563

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4
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ATLANTA, GEORGIA 30303

November 10, 2003

Mr. Kirk Stevens
Department of the Navy - Atlantic Division
Naval Facilities Engineering Command
Code 1823
Norfolk, Virginia 23511-6287

SUBJ: MCB Camp Lejeune
Draft Site 86 Pilot Study Work Plan
Operable Unit No. 20, Site 86

Dear Mr. Stevens:

The Environmental Protection Agency (EPA) has completed its review of the above subject document. The comments are entirely from EPA's Robert S. Kerr Environmental Research Center in Ada, Oklahoma. EPA Region 4 accepts the comments as written, however, further discussion is needed before consideration is given to the recommendation of using in-situ permanganate. Comments are enclosed.

If there are any questions, I can be reached at (404) 562-8538.

Sincerely,

A handwritten signature in black ink, appearing to read "Gena D. Townsend", written over a horizontal line.

Gena D. Townsend
Senior Project Manager

Enclosure

cc: Randy McElven, NCDEHNR
Rick Raines, MCB Camp Lejeune

**US Environmental Protection Agency Comments on the
Draft Pilot Study Work Plan for
Operable Unit No. 20, Site 86, Tank Area AS419 - AS421
Marine Corps Base Camp Lejeune, North Carolina**

Technical Review Comments and Recommendations:

General Comments

Overall, it is not recommended that either in-situ technologies, air sparging and air/O₃ sparging be used at this site. The rationale for this recommendation is explained below. It is also recommended that an alternative oxidant, permanganate (MnO₄⁻), be considered for use at this site. Based on a preliminary evaluation, MnO₄⁻ appears to be a viable candidate to satisfy treatment objectives.

Air Sparging and In-situ Ozonation

In Section 3.1.1, Pilot Study Overview, Page 3-1. The text states:

"Fugitive vapor emissions are expected to be minimal, although vapor monitoring will be performed. Soil vapor extraction (SVE) is not planned, primarily because of the shallow depth to water and the low permeability/heterogenous conditions of the thin vadose zone at the site."

The absence of SVE and the potential vapor impact to nearby site improvements and/or subsurface utilities is a concern associated with the pilot test and any subsequent application of the technology. Transport of volatile organics away from the sparged areas into other areas that are uncontaminated may occur. Volatile emissions may also result in unacceptable exposure pathways and risks. A health and/or explosion (if petroleum hydrocarbons are present) hazard could result from the migration and escape of these soil gas vapors. These concerns are particularly important during the Phase 1 portion of the pilot test, when cVOC concentrations are the greatest, and when only mass transfer of these compounds is occurring due to air sparging. The vapor phase of these compounds will be more mobile within the subsurface, and will have a tendency to migrate (or be pushed due to pressure differentials) through subsurface units/features offering the path of least resistance. The subsurface appears to be heterogeneous which will result in complex and/or unexpected soil gas migration patterns both laterally and vertically.

Either air sparging alone, or air sparging with O₃ without collection of volatile organics as proposed, appears to be inconsistent with most environmental strategies employed today at most hazardous waste sites. Although air sparging and O₃ sparging both have significant remedial limitations, as discussed in this review, there is a high probability that volatilization and transport

of volatile organics away from the sparge locations will occur. It is unclear whether the capture and disposal of these volatile emissions have simply been overlooked or whether this is by design. Nevertheless, this is a serious design flaw that should be more fully investigated.

Feasibility of O₃ as a Viable Oxidant in Saturated Porous Media

In Section 3.2.2.1 Chemical Processes (Pg. 3-7) it was reported that O₃ will oxidize organic contaminants in two ways, direct oxidation or generation of free radicals in the aqueous phase. Conceptualization of the fate of O₃ is described below to help identify the oxidation reactions that are involved, to explain how site specific variables at the Camp Lejeune site impact these reactions, and to understand some of the potential limitations. When O₃ is injected into the subsurface, (1) it will decompose by reacting with contaminants and other chemical species in the system directly, however, this reaction is dominated by non-target chemical species; (2) it will decompose yielding hydroxyl radicals ·OH which will also react with contaminants and other chemical species, however, this reaction is also dominated by non-target chemical species; and (3) it is possible that O₃ gas may migrate from the point of injection to the ground water surface and escape into the unsaturated zone.

The higher the pH the faster the decomposition of O₃. Dr. Raymond Sierka (University of Arizona, Tucson, Environmental Engineering Dept.) provided some data regarding O₃ stability as a function of pH. The half-life of O₃ at pH 2, 7, and 9 in water was 33 hours, 20 minutes, and < 1 minute, respectively. These examples involve relatively clean water. The stability of O₃ in the subsurface environment involving organic and inorganic mineral surfaces, the half-life is expected to be much lower. The range in pH of numerous samples collected at Site 86, OU20 was generally between 5-7 (Table 3.2 Summary of Laboratory and Field Analyses, Operable Unit 20, Site 86, CampLejeuneSite86.pdf). These values suggest that the decomposition of O₃ may be very rapid in the ground water at Camp Lejeune and that the potential for direct oxidation of ground water contaminants is limited. Distribution of O₃ in the subsurface is expected to be problematic and restricted to a zone very near the injection point. No information has been provided in this report, nor are we familiar with data and information in other published scientific literature that suggests O₃ can be effectively distributed in saturated porous media.

The reaction between O₃ and chloroethylenes is limited (Hoigne and Bader, 1979).

"The chlorine substitution of the double bond decreases its reactivity appreciably. Tetrachloroethylene reacts so slowly that it cannot be oxidized by a direct ozone reaction within a day. Trichloroethylene will only react during extended ozonation treatment."

Hoigne, J. and H. Bader. 1979. "Ozonation of Water: Selective and Rate of Oxidation of Solutes". *Ozone: Science and Engineering*. (1) 73-85.

This statement pertains to O₃ treatment of PCE and TCE in relatively clean water

treatment systems. The proposed O_3 treatment in saturated porous media will involve numerous side reactions that rapidly deplete O_3 which minimizes contact time between O_3 and the target contaminant.

There are mass transfer and mass transport limitations involving both O_3 and the contaminant. It is highly probable that TCE contaminants have been transported into lower permeable materials via advection and diffusion at Camp Lejeune. Diffusion is slow and is the predominant transport mechanism in low permeable materials. Therefore, diffusion of O_3 into, and diffusion of TCE from low permeable materials is rate limited. Based on the reaction rate of O_3 in subsurface systems, it is doubtful that the oxidant can penetrate the low permeable materials and make contact with the contaminated aquifer materials. In other words, O_3 reacts faster than it is transported and it is not possible to deliver the oxidant to some of the contaminated zones.

The reaction between $\cdot OH$ and non-target chemical species present in saturated porous media, both dissolved and insoluble, relative to the target chemical specie (TCE), is usually the predominant fate mechanism of $\cdot OH$. This suggests that the oxidative effects of O_3 on TCE, attributed to $\cdot OH$ activity, can be and often is limited in subsurface systems.

Section 3.2.2.1 Chemical Processes, Pg. 3-7 - It was reported that hydroxyl radicals ($\cdot OH$) may persist up to 24 hours in some environments. This is incorrect. Hydroxyl radicals are highly reactive intermediates and exist for only fractions of a second, probably nanoseconds. Therefore, it is unreasonable to expect that these radicals can be transported in subsurface systems.

If air/ozone bubbles were stable in a formation, better mass transfer of O_3 to the aqueous phase would probably occur. Unfortunately, there is no evidence of stable bubble formation during sparging except in gravel size media. Laboratory visualization studies clearly demonstrate that discrete regions of desaturated media (e.g., air channels) occur during sparging in all but very coarse media. The bubble versus air channel issue has been debated in the literature with a growing consensus that mass transfer is controlled by the density of air channels. It is highly probable that air channels are not uniformly distributed in saturated porous media, rather they are distributed quite heterogeneously resulting in poor distribution of O_3 . Bubbling in monitoring wells is not evidence of bubble formation in aquifer sediment because it is likely caused by air channel intersection of a borehole.

Due to gaseous flow short circuiting when air bubbles are injected into the subsurface, it is logical that the air- O_3 mixture can escape into the unsaturated zone. Assuming gas bubbles contain O_3 at the time they reach the unsaturated zone, this represents a loss of oxidant from the saturated zone. It may also represent a potential health hazard if exposure pathways of O_3 or organic vapors include human contact. This illustrates another limitation of the proposed technology.

The short circuiting process cannot be evaluated at lab-scale, but the fate of O_3 and the

oxidation capacity of $O_3 / \cdot OH$ in aquifer material could be evaluated at lab-scale. Assuming this technology is a viable candidate to be used at this site, some data and information should be presented illustrating that it can be effectively distributed in subsurface systems and that the target contaminant, TCE, can be oxidized in a complex heterogeneous system. Subsequently, it is recommended that a low cost laboratory-study be performed where the effects of oxidative treatment of TCE can be fully evaluated under site specific conditions. A laboratory study could be used to eliminate the complexities in data interpretation due to heterogeneities and fluid flow issues occurring at pilot- and field-scale. Assuming laboratory-study results are satisfactory, then a pilot-scale treatability study would be the next logical step. This information could be used to help evaluate the technical and economic feasibility of the technology. A decision to perform a laboratory-scale study should be in coordination with the other limitations identified regarding this technology, such as problems associated with delivery of O_3 into saturated porous media.

Section 3.2.2.1 Chemical Processes, Pg. 3-7 - It was reported that the ideal stoichiometry for TCE oxidation by O_3 is 1.6:1, and that most vendors use a 3:1 ratio due to inefficiencies from delivery, distribution, and side reactions. Correspondingly, it was proposed to use a 10:1 ratio for delivery. However, it is proposed that problems associated with delivery and side reactions are much greater than anticipated and that this ratio is much less than would be required.

Other Oxidants

Based on the information reviewed, it appears that the oxidant, permanganate (MnO_4^-) is a much more viable candidate oxidant to use at this site and it is recommended that it be investigated more fully. It reacts quickly with TCE, the chemistry is relatively simple, it is stable in many subsurface systems allowing for easy distribution and greater penetration into low permeable areas, does not prevent post-oxidation natural attenuation, there are numerous published reports regarding process fundamentals and field applications, and is much more developed than in-situ ozonation. It is also recommended that additional efforts and investigations to deploy O_3 at Camp Lejeune be terminated until in-situ permanganate oxidation be investigated. We would be available to provide further technical assistance to you regarding in-situ permanganate oxidation at Camp Lejeune.

Specific Comments

Presently it is unclear at this point whether in-situ air sparging and ozonation will be used at this site (although it is not recommended), site specific comments are provided regarding the deployment of this technology. Some of these comments may be applicable regardless of the remedial technology selected.

1. The use of ozone for in-situ oxidation of organic contaminants is a relatively new and emerging technology, with a limited number of available case studies utilizing this technology. This technology is mainly proven for treatment of organic compounds in wastewater, but there are major limitations to its effectiveness in treating in-situ ground water. The major limitations

are the difficulties in delivery of ozone to all areas requiring treatment, especially in complex and/or heterogenous geologic settings, the relatively short half-life of ozone, and other inefficiencies associated with chemical oxidation reactions.

Geologic data provided in the work plan suggest that the subsurface is heterogenous, consisting of sand, silty sand, clay, calcareous sands, and units composed of dense to very dense shell and fossil fragments. Figure 2-4 of the work plan provides a very general representation of the subsurface units that occur within the pilot study area and suggests that fine to medium sand and some silt occur in the vicinity of monitoring well 86-GW32IW, with these units grading to fine sands with some clay and shell fragments in the vicinity of monitoring well 86-GW33DW. This lithology and the heterogenous nature of the site's subsurface (as well as likely calcareous cementation of some of the sand units) will influence delivery and distribution of treatment gases to the areas requiring treatment. It is expected that non-uniform distribution of the O_3 will occur.

2. The work plan indicates that the pilot test will be conducted in three phases, to include one month of air sparging (Phase 1), three months of combined air and ozone sparging (Phase 2), and evaluation of system effectiveness for the most appropriate sparging technology (Phase 3). This phased approach appears to be a logical approach for evaluating the effectiveness of these technologies at the site; however, given the time frame between implementation of the phases, it may not provide data that is fully representative of subsurface conditions, particularly at the start of Phase 2. Phase 1 air sparging for a period of one month will create changes in subsurface contaminant distribution due to mass transfer, chlorinated volatile organic compound (cVOC) displacement/migration, and the creation of channels that could influence treatment gas delivery to the subsurface.

The air sparging system will be deactivated at the end of Phase 1, to allow the monitoring wells to be sampled. However, it is doubtful that there is sufficient time for subsurface conditions to return to equilibrium between the discontinuation of Phase 1 and the ground-water sampling. Thus, the ground-water sampling results will not accurately represent the equilibrium ground-water quality and the performance of the air sparging.

Further, a time period of several days (to weeks) will be required for the analyses of these performance monitoring samples, and the evaluation of the performance monitoring data will not be possible prior to the startup of Phase 2. Since the Phase 2 portion of the pilot test will be started prior to receipt and review of the monitoring data, then the baseline data will have to be relied upon when calculating ozone delivery, even though cVOC concentrations within the plume are likely to have changed. Subsequent adjustments to the Phase 2 system may have to be made once the performance monitoring data are received. This may lead to uncertainties or inaccuracies in performance evaluation of the Phase 2 portion of the pilot test.

The nonequilibrium conditions that will be present during the ground-water sampling during the ozone sparging phase of the study could also lead to uncertainties or inaccuracies in interpreting the ground-water data for performance assessment (although interpretations for

process monitoring will not be subject to these uncertainties).

3. Based on the presence of cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride, reductive dechlorination of cVOCs is likely occurring at the site. The air sparging and air sparging coupled with ozone oxidation will drive the affected subsurface to aerobic conditions, and may temporarily inhibit microbial activity in portions of the subsurface oxidized by the ozone. This is likely to inhibit the reductive dechlorination that is occurring naturally.

4. Transects of direct push sampling locations will be used to better delineate the current dissolved plume, although the direct push probe type and sampling methods are unclear in the work plan. If the direct push method allows it, installation of temporary ground-water monitoring points would allow additional process monitoring during the in-situ air sparging and ozone injection.

5. The use of a conservative insoluble tracer gas (such as helium) during the air sparging phase of the pilot test could provide assurance that the soil vapor monitoring points are appropriately placed. Detection of the helium in the vapor monitoring points would provide assurance that volatilized cVOCs or ozone would be detected if those gases were to reach the surface. Conversely, failure to detect helium in the vapor monitoring wells could indicate that the wells are improperly located to be able to detect any potential offgases.

Section 2.2, Geology and Hydrogeology, Page 2-3, Second Paragraph.

The text states: "According to Baker (RI report, 1998), there is a direct hydraulic connection between the surficial aquifer and the Castle Hayne at Site 86. The evidence includes common water level fluctuations between shallow, intermediate, and deep wells, and no evidence of the Belgrade Formation (confining layer) in site borings." It is not clear if the vertical hydraulic gradient between these hydrogeologic units has been determined at Site 86, and if so, how has it affected contaminant distribution/migration at the site. If available, this information could be included within the work plan.

Section 2.4.2, Test Area Dimensions, Page 2-4.

This portion of the work plan indicates that the pilot study target area is approximately 500 feet long and approximately 100 feet wide. Subsequent portions of the work plan also indicate the proposed screen length of the horizontal sparge well is 400 feet. Given this information, the work plan is assuming that areas as distant as 50 feet from the horizontal well will be influenced by sparging/oxidation processes. It is not clear if any prior investigative work has been done for the site that was used to derive the estimated area of influence for this pilot test. If not, it is not clear what data were used to determine that one horizontal well will be sufficient for treating the portion of the plume contained within the test area. It is recommended that the rationale for this be explained in greater detail within the work plan.

Section 3.1.1, Pilot Study Overview, Page 3-1.

As mentioned in the General Comments section above, there are significant concerns about the loss of volatile emissions during air and O₃ sparging. Because of these concerns, close monitoring of pressure changes and soil vapor concentrations is recommended throughout the proposed test area. And in addition to this, the soil vapor monitoring program should also include monitoring within nearby buildings and subsurface utilities. Should vapor impact occur that is of an unacceptable magnitude, then adjustments to system operation will be necessary, and further action may be required which may include the addition of an SVE system to recover fugitive soil vapors generated as a result of the pilot test.

Section 3.2.2.1, Chemical Process, Page 3-8, First Paragraph.

This portion of the work plan assumes a TCE concentration of 350 µg/L when estimating the volume of ozone that will be required to treat that portion of the plume contained within the proposed pilot test area. This estimate does not take into account, however, the oxidant demand that will be required for sorbed TCE, nor for the other cVOCs associated with the contaminant plume. In addition, this estimate is based on the most current analytical data (collected for the 1999 RI), and does not take into account that a portion of this dissolved phase contaminant mass will be removed from the aquifer as a result of the air sparging portion of the pilot test. These variables all need to be considered prior to calculating the mass of ozone that will be required to treat the contaminant plume. It should be noted that contaminant mass estimates are rarely accurate (mostly underestimate the contaminant mass) and usually are highly inaccurate due to the uncertainties and assumptions associated with the calculations. Perhaps the greatest inefficiency will be the inability to deliver O₃ to targeted zones, as discussed above.

Section 3.3, Pre-Pilot Study Implementation Activities, Page 3-10, First Paragraph.

This portion of the work plan indicates that a total of 25 direct push technology (DPT) soil borings will be completed within the proposed pilot test area. It also indicates these borings will be placed in five transects situated perpendicular to the centerline of the existing TCE plume. Ground-water samples will be collected from these DPT borings and analyzed in a mobile laboratory for VOCs. However, the work plan does not mention if other useful data will be collected concurrently during the installation of the DPT borings. This data would include lithologic descriptions for soil/geologic units encountered during boring installation, as well as collection of soil samples for field screening purposes. A portion of these soil samples, collected from the most contaminated portion(s) of the pilot study area, could also be submitted for laboratory analyses. This data would provide additional information relating to vertical and lateral changes in the subsurface geology and contaminant distribution that could influence the delivery of treatment gases (or other oxidants) during the pilot test. In addition, analytical results for collected soil samples would provide baseline conditions for VOC distribution within the aquifer material prior to the pilot test. Comparison of these analytical results to post-pilot test soil results (collected from within the same vicinity of the original boreholes), would provide an

additional means of evaluating the effectiveness of the pilot test in removing/destroying cVOCs.

Section 4.1, Monitoring Well Installation and Sampling, Page 4-2, and Figure 3-1.

It is unclear how well the lateral zone of influence of the horizontal well will be defined. This section of the work plan indicates that ten new monitoring wells will be installed to establish baseline ground-water quality conditions prior to horizontal well placement. The work plan also indicates that these wells will be used for subsequent performance monitoring during the pilot test. Figure 3-1 illustrates the proposed locations of these ten new monitoring wells. In the target area of 500-foot length and 100-foot width, the ten new monitoring wells will be located at "*the interior, exterior, periphery of the plume, and below the treatment area*" and "*both inside and immediately surrounding the downgradient portion of the plume*". Five of these wells will be deep and five will be shallow. The position of these wells relative to the line of the horizontal well is unclear in Figure 3-1: the wells appear to be located close to the line of the horizontal well. The three existing ground-water monitoring wells that will also be used for monitoring during the test are located farther away from the line of the horizontal well, yet might be too far to be useful. It is recommended that the location of all the monitoring wells be clarified (specifically as to the distance away from the horizontal well).

A concern with the proposed location of these wells is that they might all be placed in close proximity to the proposed horizontal well, and will not be placed at different lateral distances from this well. The proposed configuration of this monitoring well network will make it difficult to accurately monitor pilot study performance throughout the entire test area and to determine the zone of influence and/or the effectiveness of cVOC mass removal. An additional concern is that the location of these wells may be ineffective in monitoring plume movement and/or changes in plume mass distribution, particularly along the margins of the current plume. Based on these concerns, it is recommended that a portion of these wells/well clusters be relocated to provide sufficient areal and vertical coverage within the test area, over the expected width of the zone of influence. If necessary to achieve this coverage, additional monitoring wells might be considered as part of the proposed monitoring well network.

Section 4.1, Monitoring Well Installation and Sampling, Page 4-3, Second Paragraph.

The work plan states "*Soil samples will be collected from one "shallow" and one "deep" well boring at depths of 35 and 50 feet submitted for permeability testing, grain size, and TOC analysis...*". It does not, however, state whether or not any of these soil samples will be submitted for VOC analyses. A portion of these samples could also be submitted for laboratory analyses, particularly within the area(s) that contains the highest known cVOC concentration(s). This data would be useful in documenting baseline cVOC soil concentrations prior to implementation of the pilot test, and, if deemed necessary, could be used as a comparison to post-treatment soil samples collected in close proximity to these baseline soil sample locations. A portion of these soil samples could also be used for soil oxidant demand (SOD) analyses as part of laboratory-scale test(s) prior to implementation of the pilot scale test(s).

Section 4.6, Horizontal Well Installation, Page 4-8, Second Paragraph.

This section of the work plan indicates that six unsaturated zone vapor piezometers will be installed at intervals 200 feet apart on either side of the horizontal sparge well. The work plan also indicates these piezometers will be used to quantify any potential fugitive cVOC vapors and/or ozone concentrations resulting from the pilot test.

It is unclear if this degree of monitoring will provide adequate coverage within the pilot study area to determine potential offgassing from the pilot test. As indicated above, these concerns are supported by the lack of an SVE system to aid in capturing soil vapors generated during sparging, and the apparent heterogeneity of subsurface units. These conditions are favorable for preferential migration of soil gases, and the proposed number (and configuration) of vapor piezometers may not be effective in monitoring soil gas vapor migration within, and in close proximity to, the test area. The number and location of these monitoring points should be re-evaluated, and air monitoring in all nearby structures, and all known subsurface utilities should be included as part of the vapor monitoring program.

If soil vapor impact is determined to be a problem at, or within the close vicinity of, the site, then appropriate corrective actions may be necessary. These could range from reducing the volume/injection pressure of treatment gases into the subsurface, to applying SVE in the area(s) where unwanted vapor intrusion is occurring.

Section 5.1, Groundwater Monitoring.

Ground-water samples will be collected monthly from the monitoring wells during the air sparging and ozone injection and analyzed for VOCs, chlorides, dissolved oxygen, pH, conductivity, ORP, turbidity, and dissolved ozone. However, there is a possibility that air or ozone channels may intersect the well and interfere with accurate measurements of some of the parameters. Erroneous interpretations of treatment performance may also result, in which the water in the well (perhaps affected by an air channel, i.e., bubbling and stripping of volatile compounds within the well) is mistakenly assumed to be the same as the water in the bulk formation (perhaps not affected by air channels). It is recommended that consideration be given to collecting the samples or taking the measurements under semi-equilibrium conditions, after the air or ozone injection is temporarily stopped.

Section 5.1.3, Post Operational Sampling, Page 5-2.

The text states: *"Post operational sampling (i.e., after the one-year test period) will consist of annual natural attenuation monitoring, as needed."* Please note, the reductive dehalogenation of cVOCs carried out by anaerobic microorganisms will be impacted from the aerobic conditions resulting from air and O₃ sparging. This will negatively impact the rate and extent of naturally occurring reductive dechlorination occurring at the site. It is unclear how long

it will be impacted from air and O₃ sparging.

Section 5.2.1, Vadose Zone, Page 5-2, Second Paragraph.

The work plan states: *"Vapor monitoring analytical results will be used to calculate the fraction of VOCs removed by volatilization during the pilot test and also to monitor vapor treatment system performance."* First, it is unclear how this calculation of the fraction of VOCs removed by volatilization during the test will be made. Also, it is unlikely that a meaningful result will be obtained for the fraction of VOCs removed by volatilization due to the low number of vapor monitoring points, the lack of a soil vapor extraction system, the uncertain initial mass of VOCs, and the unknown but likely variable fluxes of volatilized VOCs in different portions of the pilot test area. Clarification of this calculation and reconsideration of its usefulness is recommended. Second, the phrase *"vapor treatment system performance"* is ambiguous; since SVE is not proposed for the site, there do not appear to be any vapors that will require treatment, and it is unclear what vapor treatment system is being monitored with the collection of this data. Clarification is recommended.

Section 5.2.2, Ambient Air Monitoring Procedure, Page 5-3, Third Paragraph.

The work plan states: *"Since the pilot study area is not immediately adjacent to occupied buildings, the hazard associated with fugitive emissions is not expected to be significant."* This is not necessarily an accurate statement, and as pointed out in previous comments, air quality in nearby buildings and subsurface utilities should be monitored periodically to ensure vapor intrusion is not occurring in these site improvements.

Appendix A, Sampling and Analysis Plan, Section 6.1, Soil Boring.

The description of the soil boring methodology indicates that the surficial aquifer will need to be cased off by installing a temporary casing into the silty aquitard at approximately 25 feet bgs. It is unclear if the silty aquitard described is the Belgrade Formation, and if it is actually present in the area of the pilot test. Section 2.2 of the work plan (p. 2-2) indicated that the Belgrade Formation confining unit was not present at the site. It is recommended that this discrepancy be explained and the absence of the Belgrade Formation confining unit in the pilot test area be confirmed. If this confining unit is actually present, it will lead to difficulties in distribution of the ozone.